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GIS in Geography Teaching

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Abstract

If it is true that every period of our history is marked by important revolutions which shaped its spirit and nature, today we can claim to live in what has been aptly defined, by a Pennsylvania State University project, as a “Geospatial Revolution”. Understanding the world in which we live, how it has changed and how the ways in which humans interact with it have changed, how people try to know, interpret and represent it, all provide crucial aspects for the planning of curricula, training courses and in the production of appropriate contents for them.
GIS represents an effective tool for teaching the understanding of space and place. GIS finds application in various fields from natural science and geology to sociology and anthropology, from political sciences, economics and urban studies to archaeology and history. The use of this tool enables the introduction of research methods in geography teaching, leading, for example, to the acquisition of the ability to create a conceptual model of reality that can be studied as well as to select the most useful data for this purpose, to interpret it independently, and to represent it effectively.

Keywords: Geospatial Revolution, Open GIS, Open Data, Geography Teaching, Geobrowser

1. Geo-literacy and Geo-skills

If it is true that every period of our history is marked by important revolutions which shaped its spirit and nature, today we can claim to live in what has been aptly defined – by a Pennsylvania State University project – as a “Geospatial Revolution”[1]. PennState scholars have defined a set of complex scenarios, represented in a series of short videos, in which possible uses and development of geotechnology, today increasingly immersive and pervasive, are unfolded. Accordingly, new forms of interaction between individuals, groups, and information technologies emerge.

Understanding the times and the world in which we live, how it has changed and how the ways in which humans interact with it have changed, how people try to know, interpret and represent it, all provide crucial aspects for the planning of curricula, training courses and in the production of appropriate contents for them.

[1] http://geospatialrevolution.psu.edu/.

Recent surveys[2] conducted in the United States and Canada show an overall scarce geographic knowledge – especially among the younger groups of the population. We lack similar surveys regarding our country, Italy. *Invalsi* – the National Institute for the Evaluation of the Educational System – provides national data on reading, mathematics and Italian and OECD-PISA data refer to reading, mathematics and science skills only. Therefore, since we do not have statistical data to base our studies on, we have to rely on more or less structured reports and experiences carried out by teachers who are directly in contact with children and young people or base our assessments indirectly from published case studies. Generally speaking, the increasingly marginal role that geography is playing in the Italian school system does not lead to the conclusion that the need to master, or even develop, solid geographical knowledge is currently being perceived.

Thus, it might perhaps be timely, in this particular moment of history, to consider what Geography should teach, what studying Geography should mean, and what the most appropriate tools to achieve this are.

Geographical facts or concepts do not represent strong assets if nothing can be done with this knowledge. We could say that today's main need is not to possess geographic information but, instead, to be able to do something useful with it. That is to say to be able to process this data and knowledge in order to produce geographical knowledge and to act geographically and globally; these capabilities constitute a further development away from the simple possession of geographical information. This is what we mean by the term *geographic literacy*. The problem is that most teachers, for many reasons, mainly related to their initial training, lack of classroom time and general difficulties in the present Italian schools, often find themselves uneasy with the concept of what it means to "do geography" and are forced to adopt traditional teaching methods, in which the concept of geography is reduced to a list of capital cities, tables with numbers regarding inhabitants, gross domestic product and so on, with the final result of turning students away from geography books and mortifying their curiosity instead of stimulating it.

This picture changes totally, however, when it is realized that you can extract meaning from apparently sterile and boring information, when you can elaborate meanings, identify connections and relationships, in other words when you can manipulate information so as to produce knowledge.

"Everything happens somewhere" and everything that happens is in some way connected to a place, has geographic coordinates, is, in other words, geo-referenced, and, we must add, also refers to a specific historical moment. Space and time dimensions can be managed and represented within a Geographical Information System. Those who master and use a GIS know what it means to analyze and solve geospatial problems, because they are used to applying the analysis of spatialized information, in complex situations in order to understand geographical, social, economic, cultural phenomena. Hence forecasting trends can be extrapolated, plans developed, decisions made. Doing geography while also using GIS means understanding how important the ability to do geography is for ourselves and even for the entire community.

"Knowing where things are is only the first step in attaining geographic literacy. Ultimately, geography is concerned with understanding why things are located where they are. To answer this type of question requires the use of a wide range of geographic themes, concepts, and skills" (Backler and Stoltman, 1986).

The National Geographic Education section has promoted the sharing of standards regarding skills related to geographic literacy, especially in view of "lifelong, life-sustaining, and life-enhancing" learning. We all must be aware that the next generations will face problems regarding overpopulation, reduction of resources and energy production, market globalization, quality of life and food security. It is therefore vital that schools provide the instruments which enable responsible behavior and contribute to decisions useful for the well-being of the communities in which they will live and work.

[2] National Geographic Society - The National Geographic Education Foundation, 2006.

Below is the list of Associated Geography Standards, which can be traced back to the following macro-areas: the World in Spatial Terms (1-3), Places and Regions (4-6), Physical Systems (7-8), Human Systems (9-13), Environment and Society (14-16), the Uses of Geography (17-18):

“1. How to use maps and other geographic representations, geospatial technologies and spatial thinking to understand and communicate information

2. How to use mental maps to organize information about people, places, and environments in a spatial context

3. How to analyze the spatial organization of people, places and environments on the Earth’s surface

4. Physical and human characteristics of places

5. People creating regions to interpret the Earth’s complexity

6. How culture and experience influence people’s perceptions of places and regions

7. Physical processes that shape the Earth’s surface patterns

8. Characteristics and spatial distribution of ecosystems and biomes on the Earth’s surface

9. Human populations, characteristics, distribution and migration on the Earth’s surface

10. Characteristics, distribution and complexity of the Earth’s cultural mosaics

11. Patterns and networks of economic interdependence on the Earth’s surface

12. Processes, patterns and functions of human settlement

13. How the forces of cooperation and conflict among people influence the division and control of the Earth’s surface

14. How human actions modify the physical environment

15. How physical systems affect human systems

16. Changes occurring in resources, meaning, use, distribution and importance

17. How to apply geography in interpretation of the past

18. How to apply geography to interpret the present times and plan the future”.

2. Why use GIS in teaching Geography?

Why use GIS in teaching Geography? Firstly, for the potential that GIS provides in the visualization, management and analysis of geographic data; for its effectiveness in producing and changing cartography; for the versatility in output production (maps, graphs, three-dimensional models, virtual scenarios); for its ability to integrate different databases; but, above all, for its effectiveness in teaching how to organize thought and research.

“Spatial thinking is as important as logical thinking or quantitative thinking; it is a cognitive skill necessary to understand the ubiquitous influence of location. Looking at a location is an inherently cross-disciplinary undertaking” (Stuart Sinton and Lund, 2007, p. 9).

Daniel Edelson, vice president of the United States of America National Geographic Society, writes – referring to his country but with observations that are valid for many other national contexts, including Italy.

“I believe that every [citizen] should understand how the attributes of a location and its relationship to other locations affect that location. Every adult should understand that his or her actions have predictable effects elsewhere and that what happens elsewhere affects them. Today, [people] go from kindergarten through college without ever being taught how to trace causes forward or backward across space or to analyze spatial relationships in order to predict or explain. Without this analytic ability, how would we ever expect them to make good decisions about where to live and work, how to transport themselves, what to buy and how to dispose of it, how to prepare for natural disasters, whether to go to war abroad, where to locate a store or factory, or how to market goods abroad? The list goes on and on" (Edelson, 2009).

These questions can be answered if one acquires the tools necessary to evaluate the distribution, in a given territory, of a phenomenon, a characteristic, a criticality, or a resource.

The multifaceted influence of place should be studied for many reasons and a GIS represents an effective tool for teaching the understanding of space and place.

The use of this tool enables the introduction of research methods in geography teaching, leading, for example, to the acquisition of the ability to create a conceptual model of reality that can be studied as well as to select the most useful data for this purpose, to interpret it independently, and to represent it effectively[3].

GIS finds application in various fields: natural science and geology, sociology, anthropology, political sciences, economics, urban studies, archaeology, history. One can explore social diversity or examine spatial patterns from global to local; assess neighborhood opportunities or build a geodatabase of an archaeological survey; promote environmental, cultural and landscape heritage; evaluate land use changes or investigate soil erosion.

3. GIS Open Source in Teaching Geography

There are many GIS tools available[4]. All products share the main functions, then each of them develops special features that enable it to carry out specific analyses or to treat specific data. Some of these products belong to Open Source Software (OSS) and are very suitable for teaching as they can be installed, used and customized freely while respecting the work of others and the user community. Among the most popular open source GIS software[5] GRASS and QGIS are undoubtedly worth mentioning. GRASS (Geographic Resources Analysis Support System) is a very powerful GIS with functions ranging from spatial analysis to environmental modeling, from the generation of theme maps to DBMS integration, from two and three-dimensional spatial data viewing to the storage and management of information layers.

QGIS can display and edit vector data, raster, and database connections and can be used in different environments (Linux, Unix, Mac OSX, Windows) and, thanks to a special plugin, as a user-friendly GRASS interface (Figure 1).

[3] This methodology has finally found acceptance in the new Italian ministerial programs related to basic education, as happened long ago in many foreign countries.

[4] Among the most common applications, there are:
ArcExplorer (http://www.esri.com/software/arcgis/explorer);
ArcGIS (http://www.esri.com/software/arcgis);
AtlasGIS (http://rpmconsulting.com/atlas);
AutodeskMap (http://www.autodesk.com);
GeoMedia (http://geospatial.intergraph.com/products/GeoMedia/Details.aspx);
GRASS (http://grass-italia.como.polimi.it/link.php);
Idrisi (http://www.clarklabs.org);
MapInfo (http://www.pbinsight.com/welcome/mapinfo/);
QGIS (http://www.qgis.org).

[5] Other valid open source software that can be used in teaching and research are: gvSIG which has a user-friendly interface allowing easy print layout creation and supports vector and raster formats (http://gvsig.org / web /). OSSIM (Open Source Software Image Map), a high-performance tool for remote sensing image and photogrammetry (http://trac.osgeo.org / OSSIM /) management and processing. MapServer excellent for building web applications dedicated to spatial data publication (http://mapserver.org/). DeeGree Java Framework provides the main software blocks for spatial data infrastructure construction according to the standards of the Open Geospatial Consortium (http://www.deegree.org). Mapbender, created in PHP and Javascript and distributed through the GNU license allows for the creation of access portals to geographic data (http://www.mapbender.org / Mapbender_Wiki). MapGuide allows web mapping applications and web services development and distribution, it includes an XML database for content management and supports all major formats of geospatial data and database connection. It runs on Linux and Windows and it is licensed through LGPL (http://mapguide.osgeo.org). OpenLayer can display a dynamic map on any web page and provides navigation and search tools with no need for the user to install anything and it implements the WMS, WFS standards (http://openlayers.org).

The release 2.0 contains new features both in terms of the user interface and in the data provider system.

The map composer and the editing tools are much more powerful.

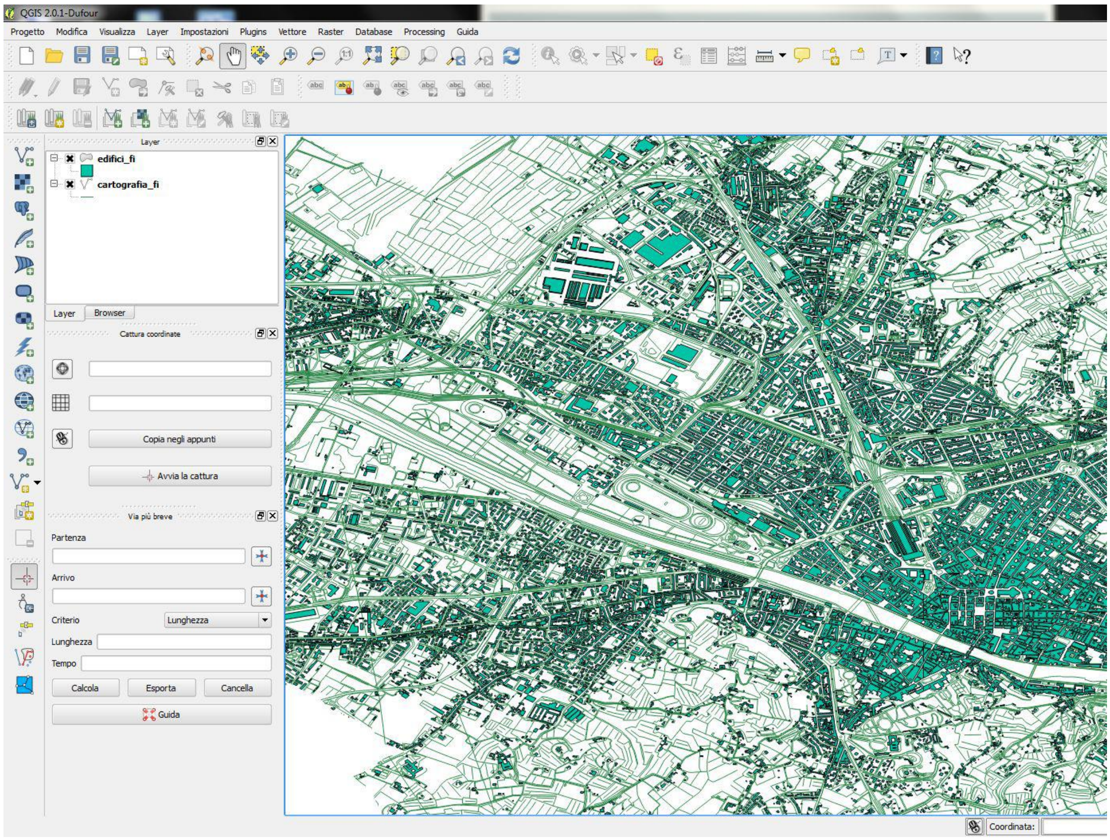

Figure 1. The new layout of the latest release of the Q-GIS 2.01 Dufour. In this picture, showing a work session with the teachers, you can notice the graph vector layers of the streets and the buildings in the city of Florence.

Thanks to this software, different format maps can be uploaded, overlaid, changed in projection, reference system and display characteristics. One can modify individual information layers, by adding or removing elements, create new vector layers (points, lines, polygons), create thematic maps, select specific areas, and create printing or screen viewing output[6].

[6] Numerous projects of the Italian Association of Geography Teachers have been devoted to the use of QGIS, starting from the project "Geographic Information Systems. Opportunities for integration between nature and technology and new tools for the dissemination of scientific culture" carried out in Italian lower and upper secondary schools (2009).

Yet having powerful, free, and easy-to-use software is not enough. It is also important to have reliable data which can be integrated into the system. New information layers can be easily produced thanks to the editing tools offered by any GIS but, in most cases, data must be obtained from organizations or businesses and then implemented into the system.

Learning how to convert different projections, reference systems, and tabular data integration from different formats, becomes then of paramount importance.

To ensure ever greater interoperability between systems and databases produced in different times and for different purposes, research communities and public administrations are planning and creating infrastructures in which to share geographic data (Web Map Services) and they are standardizing documentation with the aim of sharing produced data and of certifying its quality (Metadata).

The main limitations to research product sharing are, as a matter of fact, due to the different data forms and formats used from time to time, the choice of the platform, and the documentation which is often missing or scarce. For this reason, it is necessary to define beforehand standards and implementation specifications that allow for easy information exchange and ensure compatibility and interoperability between formats, platforms, and documentation devices.

The Open Geospatial Consortium (OGC) was created to satisfy these needs. It is an international consortium consisting of over 280 companies, research institutions and administrations whose aim is to develop, in an agreed upon manner, specifications that facilitate data interchange (http://www.osgeo.org). These OGC specifications are public and available for free.

The Italian Digital Agenda has produced an important tool, the National Directory of Spatial Data (RNDT), to conduct research, through metadata, for spatial data available at public administration offices; to assess their compliance; and to obtain the necessary indications concerning the conditions of access and usage. This system was recently equipped with the possibility of harvesting metadata produced by each of the administration offices which now publish data in accordance to the given guidelines[7].

Learning how to document produced and distributed data is of fundamental importance not only within the fields of public administration and research, but also in education. A layer of information can be reused in the future only if it is accompanied by a series of facts about the author, the purpose for which it was produced, the date of creation, the update frequency, the characteristics of the attributes related to the geometry, the projection and reference systems used, data accuracy, the acquisition and the best display scales. Documenting information also means to further verify it and, from an educational point of view, it is a useful exercise in order to consolidate knowledge and greater assessment of the work done. Every GIS provides tools to create specific documentation apparatus.

4. From WebGIS to WebService: an opportunity for teaching Geography

Knowing the allocation, availability and limitations in the use of various layers of information that are considered necessary for a project is a need felt at all levels: from education to research and in the fields of land management. It is precisely for this reason that the greatest efforts have been made in the field of geographic data sharing.

Data publication and distribution strategies are ascribed to two technologies which are similar in appearance, but very different in substance: WebGIS and WebService.

A WebGIS enables the publication of geographic content through an interactive web page that does not require the installation of specific GIS software by the client. On the other hand, a Web Service allows interaction through GIS browsers or open source software only with geographic data expressed as specifically defined by the Open Geospatial Consortium. Formats allowing such interaction are WMS (Web Map Service), WFS (Web Feature Service), WCS (Web Coverage Service), WMTS (Web Mapping Tile Service) and WPS (Web Processing Service).

A WebGIS provides information (maps and metadata), also allows you to interact with published data layers that can be selected or deselected to create custom maps, to measure distances or areas, but it does not allow you to download/edit the published geographic content.

On the contrary a WMS provides the user with a map defined in size and with geographic parameters. Its metadata can be “invoked” or called back up, viewed and modified via a GIS desktop.

[7] http://www.rndt.gov.it/RNDT/home/index.php.

In fact an OGC WMS, as specified in the vast online documentation, dynamically produces maps of spatially related data starting from geographic information. A map, in the sense of geographic information representation, can be turned into a digital image which can then be displayed on a computer screen. A map can be produced in an image format (PNG, GIF, or JPEG) or, more rarely, in vector format.

Through QGIS one can easily access resources provided by a WMS. One need only to open the programme, select the option from the Layer menu add a WMS layer, select a new connection, give it a meaningful name that allows you to recover it in the future, and copy the URL (Uniform Resource Locator) in the provided space. When requesting a map the URL indicates what information should be displayed on it, which portion of the Earth must be represented, the desired coordinate system, the format and size of the output image. The URL can be simply copied from a cartographic portal web page which supports this service. Different maps can be obtained from different servers and, if they are produced with the same parameters and geographic sizes, these can be overlapped to build customized maps capitalizing on the possibility to interact on the layer transparency.

Through this above-mentioned procedure, it is also possible to "invoke" via http a Web Feature Service (WFS). While an OGC Web Map Service allows the user to capture images from multiple servers, an OGC Web Feature Service allows you to retrieve geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services. A WFS service describes the operations of research and processing of vector data.

5. The National Geoportal and other geo-services

Among the main online resources, the National Geoportal – which belongs to the Department of Land Defence within the Ministry of Environment, Land and Sea– is definitely worth mentioning. This resource allows the display and use of national cartography and many other geographical data.

The strategic aim of the National Geoportal is "to promote and spread the use of Geographic Information Systems, to make environmental and territorial information available to a wide audience including non-experts, taking into consideration the projects and current activities at national and European level" and to allow "anyone with an Internet connection – scholars, researchers, administrators, private citizens – to view and use, for free, the desired cartography by selecting it as if it were on the shelves of a library"[8].

All the maps provided by the portal are accompanied by a documentation (metadata) apparatus showing the exact content of the available data so that it can be effectively reused. All cartography is produced by public administration authorities, or made available by a network of peripheral offices which cooperate with the Ministry of Environment.

Maps produced by the Military Geographic Institute can be acquired; orthophotos, digital terrain models (DTM), information layers related to human territorial occupation (administrative boundaries, place names, railway lines, roads, ...); topics related to geology and geomorphology (geological map, bathymetric map, ...); land cover documents (CORINE); protected areas; physiographic units; risk of coastal erosion and numerous other data (Figure 2).

The National Geoportal is, in fact, the core of a technological infrastructure aimed at the efficient exchange of geospatial meta information, relating to territorial and environmental data, called Cartographic Cooperating System (SCC).

[8] http://www.pcn.minambiente.it/GN/.

Figure 2. The National Geoportal WebGIS service. The image refers to a practice exercise with teachers. Some layout vectors showing the railway and road infrastructures and the distribution of schools in the city of Modena were superimposed onto the orthophotomap of Italy.

The Cartographic Cooperating System provides services and access to a set of information layers and data archives covering the whole nation (Reference Cartographic Base) and local areas hosted by local Cooperating Bodies, i.e. by public and research companies, institutions and public firms that have decided to join the project[9]. Through the INSPIRE Project (Infrastructure for Spatial Information in Europe)[10] this system is also available to European and international partners, aiming towards achieving the more effective coordination of Community environmental policies. According to the guidelines adopted as part of this project, those who create a new geographic data sharing infrastructure must ensure public services tailored to users' needs, it must be easy to use, accessible via the Internet (desktop or mobile), and, in particular, it must provide collected and managed territorial datasets: metadata research services that must be visualized, consulting services, services for data download, conversion services enabling the transformation of spatial data sets (interoperability); services allowing recalling of spatial data services.

The metadata catalog is in fact the gateway to available data and services. A metadata relating

[9] Among the cooperating entities there are local authorities, basin authorities, research facilities and universities. The Applied Geography Laboratory of the University of Florence joined the SCC thanks to the geodata service available at http://www.geografia-applicata.it.

[10] The INSPIRE Directive defines the system of the infrastructure for Spatial Information in the European Community, based on the infrastructures for spatial information established and operated by the Member States. This infrastructure is composed of: metadata, spatial data sets, data access services, network technologies; sharing agreements, data access and use, coordination and monitoring processes and procedures.

to a particular resource can be used in the identification and research of the resource itself, as well as in the understanding of the quality and information content.

Other interesting geo-services have been made available by some regions and municipalities.

The Toscana Region Geographic Service, for example, has developed GeoScopio_WMS (http://www.regione.toscana.it/-/geoscopio-wms), a module for the consultation of maps, 2D based thematic geographic data, through user-GIS. The Region of Sicily, the first among local governments, has published a GIS Regional catalogue according to the RNTD specifications that enable metadata harvesting (http://www.sitr.regione.sicilia.it/geoportale). Other regions such as Piemonte, Veneto, Lombardia, Sardegna offer WMS services.

The aim of the OpenData Project of the Firenze Municipality (http://opendata.comune.fi.it/index.html) are improving the access and the integrated use of geographic data and information, promoting interdisciplinary approaches to sustainable development, improving the knowledge of the benefits of the geographic information. The opensource GeoNetwork allows to simply share geographic information (interactive maps, GIS data, satellite images) related to different themes (environment, demography, mobility, economics, culture and tourism, …) and regions among different organizations.

For teaching purposes the ISTAT portal can be very useful. It provides geographic data in shapefile format for the years 1991, 2001 and 2011 (administrative boundaries and local work systems), the territorial infrastructure statistical atlas, the geography and administrative statistics atlas; the municipal statistic atlas and the database data on municipal scale that allows the consultation, export and cartographic representation of information (from 1971 for population / housing and industry / services, from 1990 for agriculture) relating to territory, population, health, education, tourism, culture, credit, vehicles on the road.

Data can be extracted and viewed according to a vast set of pre-defined territorial partitions (regions, provinces, municipalities, mountain communities, local work systems, local health authorities, etc.), or through municipality customized selections.

Other useful national geoportals include Géoportail, the French mapping portal (http://www.geoportail.gouv.fr/accueil) and Geoinformació digital set up by the Cartogràfic Institut de Catalunya (http://www.icc.cat). Thanks to these services one can add GIS project layers of information made available by organizations and institutions in order to obtain maximum sharing.

Not to be forgotten, finally, the UN Geoportal and the projects carried out as part of the United Nations initiative on Global Geospatial Information Management (UN-GGIM).

The GEOPortal provides convenient access to the full range of GEOSS data and information, under the leadership of the Group on Earth Observations (GEO). Operated by the European Space Agency and the Food and Agriculture Organization of the United Nations, it provides a web-based interface for searching and accessing data, information, imagery, services and applications. It connects users to a variety of data bases, services and portals that provide reliable, up-to-date, integrated and user-friendly information – vital for decision-makers, managers and other users of Earth observations in their jobs. The content available through this Portal continues to expand at a rapid rate and bodes to reach a critical mass in the near future.

The UN Cartographic Section (UNCS) is developing global multi-scale geospatial datasets for rapid map production and web mapping in support to the Security Council and the Secretariat including UN field missions.

The Global Mapping Project, launched in 1996, is an international cooperation initiative that aims to develop a digital geo-information framework ensuring spatial resolution at 1 km, with standardized specifications and available to everyone at marginal costs. Global Map datasets consist of 8 basic layers (Boundaries, Drainage, Transportation, Population Centres, Elevation, Land Cover, Land Use, and Vegetation) for currently 71 countries and 4 regions, collectively covering 60% of the whole land area. Global maps of elevation, land cover and vegetation (% tree cover) layers wholly cover the globe land area.

The UN Cartographic Section (UNCS) is developing a GIS-based UN International Boundary Information System (UNIBIS) that provides a knowledge base of international boundary issues with treaties, relevant documents, maps and satellite images along with the actual status of disputed boundaries in support to the Security Council and the Secretariat as well as the Member States. The objective of this knowledge is to prevent potential conflicts, resolve border disputes and support border demarcations and to promote cross-border cooperation.

Another project, launched in 2001, the Second Administrative Level Boundaries (SALB) dataset, is providing the international community with a working platform covering all UN Member States for the collection, management, visualization and sharing of data/information down to the second administrative level.

The UN Cartographic Section (UNCS) is developing a global place name database and search engine (or UN Gazetteer) in support to the Security Council and the Secretariat including UN field missions. Many place names have multiple spellings. A location search may not show up in the results even though a different spelling is in the database. Searching through phonetic spelling solves this problem. Lessons learned indicate that in emergency situations it is difficult to locate the effected place on the map which of course hinders response time. Situational intelligence also depends on locating place named events. These challenges can be avoided/reduced through the development of a UN Gazetteer that would collect, update and validate place names with geo-coordination from UN field operations and NGOs as well as the Member States.

The World Geodetic System defines a reference frame for the Earth, for its use in cartography, geodesy and navigation. The latest revision is WGS 84, dated 1984 (last revised in 2004), which will be valid up to about 2010. WGS 84 is the reference coordinate system used by the Global Positioning System. The US National Geospatial-Intelligence Agency (NGA) develops, maintains, and enhances WGS 84.

6. Virtual globes

Mapping services are increasing in popularity day by day, both those exclusively present on the web (Googlemaps, OpenStreetMap, Bing, Yahoo! Maps, Maps of Apple), and those with interfaces installed by users, such as virtual globes including Google Earth and NASA World Wind.

The ability to handle a large amount of geographic information in a very short amount of time has contributed to their success. This is possible thanks to technology that processes data in small 256 x 256 pixel tiles, organizing them in simple spatial coordinates.

This organized fragmentation helps reduce the load of handled data, which is rendered only in the windows visualized. In this way, one can quickly browse thousands of aerial photographs and satellite images, dozens of vector data layers such as place names, administrative boundaries, roads, infrastructures and natural emergencies.

Developers have paid particular attention to elaborating highly intuitive information search software, and to making these also available on mobile devices with touchscreen interfaces.

These applications have great educational potential thanks to the diversity and heterogeneity of the geographic data presented, and thanks to the presence of different reprocessing tools.

Let us now consider Google Earth, in its standard version, because of its popularity among the public in general. This software, privately owned but released as freeware, distinguishes itself from other unprofessional mapping programs, for the possibility it provides to customize data thanks to some of the most popular tools in the GIS field. It is therefore very suitable for exercises that can be conducted in computer labs in schools.

Firstly, it is clearly an environment of integrated consultation: an all-embracing territorial reading is possible, whether it is a micro-area or a macro-area. For example one can start with a purely morphological survey observing the Earth's tectonic development, moving then to the shape of the continental plates of the great continental formations, following their development on a three-dimensional model, shifting then to human geography observations, analyzing satellite photos, and finally arriving at the changes which have occurred in the course of human history.

Already at this level of usage, which requires no special computer skills, but simply the understanding of the intuitive navigation tools like zooming and moving the line of vision, one can draw inspiration for any topic related to the school curriculum, thanks also to the image quality, which often "speaks for itself".

There are, however, additional features in the software, which are oriented towards a purely educational use: one can even consult the catalogues of historical maps, like the famous David Rumsey collection, or even add current or old maps to the virtual globe thanks to the Add Image Overlay function on the GE toolbar, a tool that, in fact, allows georeferencing the image that you choose to overlap.

GE also allows you to interactively create your own maps and add precise, linear, polygonal, and even three-dimensional information layers. You can, for example, draw an itinerary through a polyline. It is a simple task that can constitute an initial introduction to the main features provided by a real Geographic Information System (Figure 3).

To create custom geometries you simply need to select the desired item from the toolbar in the icon section. Through this action a window opens where you can define the graphic properties of the element that you want to draw.

After each click on the background single marker elements are added, the vertices of a line or of a polygon.

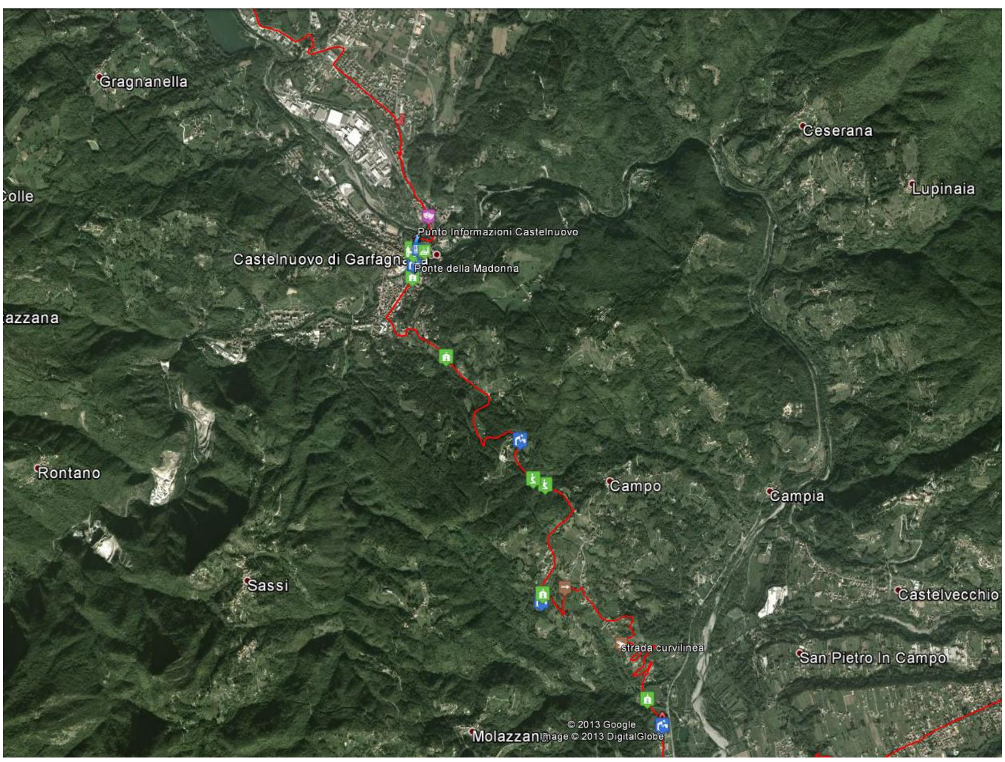

Figure 3. Displaying a route on Google Earth geobrowser. These tools can be extremely useful in the enhancement of cultural and tourist routes, as one can add notes, additional information and customized symbology.

There are several exercises that can be proposed to students, from the most basic ones like drawing a specific route, such as a school trip, to more complex ones such as articulated routes or even digitizing historical or environmental emergencies.

You can import or export your files in a KML/KMZ specific format in GE files. KML is a language developed to manage geospatial data in three dimensions based on XML format. This means that a single KML file can be processed and also developed through editing tools such as Notepad provided by Windows or other similar software.

In other words, Google Earth, when used under the guidance of a teacher, is a valuable tool to awaken the student's awareness of space and geographical distances. It is also important in understanding the topological relationships between objects that persist in a given area, and most importantly, in learning about our world, without interpretation filters, but simply through direct image observation.

7. Teaching geography in schools with Smart Mapping, Interactive White Boards and GIS

The Smart Mapping project was developed through the collaboration between the Applied Geography Laboratory and some Tuscan businesses that specialize in the development and diffusion of information technology (Figure 4).

It was created with the idea of showing geography teachers the intrinsic GIS and geobrowser potential when teaching the subject and, at the same time, it took advantage of the recently initiated educational innovation process which has provided multimedia interactive whiteboards or smart boards (IWB) in many Italian middle and high schools.

The "2.0 class" environment in fact, developed around the synergy between new technologies and rejuvenation of traditional teaching, perfectly suits the study of geography through such modern tools[11].

Figure 4. The Home Page of the Smart Mapping project, set up by the Laboratory of Applied Geography of the University of Florence.
Source: http://www.geografia-applicata.it.

After all: "Geography teachers have always needed various tools for visual communication, which bring the world and its spaces into the classroom: large or small, near or far, related to the present or to the past. The teaching of geography can therefore benefit considerably from both the recent acquisitions of scientific research and from the new technologies for the representation of territory" (De Vecchis and Pesaresi, 2011, p. 16).

Specifically, Smart Mapping is configured as an innovative "container" of knowledge and tools, designed to explain in a clear and efficient way the history of cartography from its beginnings to the latest digital era achievements. Thanks to hypertext and to the web-oriented nature of IWBs, many ideas can be provided on how to use the instruments, as extensively discussed in the previous paragraphs.

After all, we are all cartographers today: we can produce digital maps, post the places we

[11] This term refers to the Cl@ssi 2.0 project, promoted by MIUR and INDIRE, aimed at the creation of: innovative learning environments, digital educational contents and teaching methods based on the use of the new technologies available to both teachers and students, first of all the IWB. For more information on this and other projects, please see: http://www.scuola-digitale.it/.

stop at or where we live online, gather and send real-time information with our smartphones endowed with a GPS navigation system, transform the network into a geographical means of shared communication. So much so, in fact, that people talk of the GeoWeb, doing what a short time ago only professional cartographers could do: represent the world, helping spread geographical knowledge.

Despite all this, geographical knowledge has never been as underestimated as it is in schools today. We must therefore promote a new image of the subject that, starting from basic education, is able to bridge the gap between geographical research and teaching, so that knowledge and innovative methods can fully contribute in forming students' critical personalities, autonomy, and self-awareness, according to their different ages.

The Smart Mapping Project takes its place in this scenario in which IWBs in the classrooms may be the key to a significant change in this unfavorable trend.

As is widely known, a multimedia board is an interactive surface on which the video output of a computer is reproduced. However, the board is able to operate simultaneously as an input device too, acting as a large touch screen[12]: this, together with the necessary Web infrastructure, allows the geography teacher to bring to class a number of tools for the production and study of geographic information, which then remains at the students' disposal.

In this context, though, the first priority is the need to train the teachers, and not just the students, to manage and get the best use out of these tools, making them aware at the same time of its numerous opportunities, in terms of data and additional software, currently offered in internet.

In order to meet all the above-mentioned needs, Smart Mapping became a project structured in two distinct phases, one the continuation of the other, targeted at students as well as at their geography teachers. The initial program, dedicated to cartography and GIS knowledge using the IWB potential, was supplemented with a second and more technical phase, targeted at the actual training of teachers in the use of these new technologies.

Smart Mapping was presented for the first time as a workshop at the 2012 ABCD Congress on education, orientation and the working world in Genoa, where it received enthusiastic evaluations from teachers and experts. It later became the cornerstone in the teacher training course "IWBs and Geography", sponsored by the University of Florence and AIIG - Tuscany. It was included in the workshops organized for the TFA 2012/2013 regarding the A039 class – Geography, held at the University of Florence. It was during this first presentation stage, that the preconditions for the testing of the second part of the project were created, involving some geography teachers in technical institutes for tourism of the Florentine territory.

These meetings triggered the use of one of the leading GIS open source softwares currently available, QGIS, and led also to the acquisition of the logic and main features of this software, such as the technical knowledge necessary for the understanding of problems related to its management and the development of geographic information through this specific digital instrument.

Teacher training was done through the use of specific free tutorials downloaded from internet (such as *Introducing GIS*, http://linfiniti.com/dla/) and other materials specially produced and shown to the teachers.

The IWB proved to be an extremely captivating instrument, fostering on one side better dialogue between trainers and teachers involved in the project, and on the other a clear vision of the tools and their operation.

Furthermore, part of the training was specifically dedicated to the use of online resources. Among these, for example, we should mention the geobrowser Google Earth Thematic Mapping Engine application

[12] For more information on this device, among many other sources, please see: Betcher and Lee, 2009; Bonaiuti, 2009; Zambotti, 2010; Beauchamp and Parkinson, 2005, pp. 97-103; Magnaterra, 2010, pp. 20-26; Leonardi, 2012, pp. 11-17.

(http://thematicmapping.org/engine/)[13], which provides the tools to generate thematic maps based on statistical data provided by the United Nations. On the web reference page it is possible to select a statistical indicator, set the data representation techniques (graphics, colours, scale indicators), choose the time frame (one single year, a group of years, all the way to a timeline animation), create the map layout by adding the title, comments, labels and key and, once the various parameters have been established, produce a specific .kmz file, viewable directly on Google Earth (Figure 5).

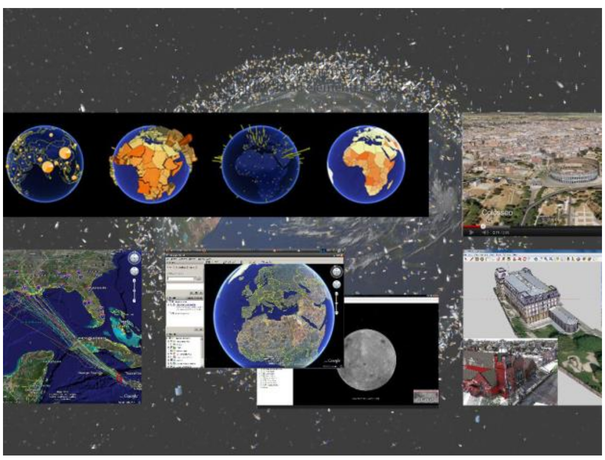

Figure 5. Smart Mapping, introductory page dedicated to virtual globes and their possible uses.
Source: http://www.geografia-applicata.it.

The main purpose of this first phase of the project was therefore to get the teachers acquainted with the modern geographical and cartographic languages, necessary for the understanding of the many features of this subject's contemporary communication: a complex vocabulary that uses multiple new sources, often to be integrated among themselves, so as to be able to effectively use the current geo-graphic languages.

We are currently working on the presentation of the project to the students inside classrooms, configured as a complete learning module, involving the same previously trained teachers who have expressed their willingness to continue this collaboration.

This didactic activity will be conducted following specific planning based, firstly, on the assessment of the students' prerequisite knowledge, carefully measuring the contents, the educational strategies and the activities to be carried out.

Smart Mapping will be divided into three teaching units (What's a map, A brief history of cartography, and We are all cartographers) calibrated for the first year of the Tourism Technical high school (Figure 6). In the first unit, discussion will be conducted on how to realize a plane which is a reduced, approximate or symbolic representation of a place, introducing the fundamental concepts of geographic coordinates, map projection, scale reduction and conventional symbols.

In the second unit the long and fascinating history of cartography will be summarized, and it will be closely linked to the evolution of its knowledge and techniques, but also to past and present political and cultural choices. Finally, in the third unit the foundation will be laid for the knowledge of the tools and cartographic techniques offered by internet, and more generally by all computer sciences.

Figure 6. Smart Mapping, index of its three Teaching Units. Clicking on each icon, one can access each specific content.
Source: http://www.geografia-applicata.it.

[13] This interesting project, conceived by Bjorn Sandvik, is based on the use of KML (Keyhole Markup Language) to create thematic maps. For further information on the author and on the methodology, refer to http://thematicmapping.org/.

The defined objectives of the project will be discussed in class at the beginning of the activities and at the end in order to evaluate the skills effectively learned concerning: competence (in the use of appropriate geographic and cartographic language, how to correctly read a map, how to properly use web resources for basic geo-mapping operations) and knowledge (the main stages in the history of cartography, social and cultural causes underlying cartographic production, world exploration periods, distance planet vision and study of our planet through the use of geobrowsers, monitoring our surrounding environment).

In conducting these lessons effort will be made to limit the traditional frontal teaching methods in favor of more engaging teaching techniques, providing interactive exercises, online geography games and, mostly, the assisted use of everyday available tools such as the Google Geo Educational Package (Map Maker, Street View, Google Earth).

In this project the presence of an IWB in the classroom is essential in presenting the teaching units and the materials available for practice, providing with its tools added value to the lessons themselves, integrating and facilitating the presentation of the topics and stimulating the students' attention through the activation of multiple perception and learning channels.

The IWB will allow for easy alternation between frontal teaching and individual or laboratory activities. In fact, this approach should be particularly appreciated by the students, who are now used to daily decoding information according to the modern communication rules of our digital world. Yet it will also be functional for the teacher, because the IWB will keep the students' attention on the lesson thanks to the innovative methods. It will also use the instrument's versatility and the connection to online educational resources and information available to help in introducing and explaining more complex concepts, making the best use of the classroom time.

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References

1. Anderson P., “What is Web 2.0? Ideas, technologies and implications for education”, *JISC Technology & Standards Watch*, 2007, http://www.jisc.ac.uk/media/documents/techwatch/tsw0701b.pdf.
2. Andreucci G., *Google Earth e Google Maps*, Milan, FAG, 2011.
3. Backler A. and Stoltman J., “The Nature of Geographic Literacy”, *ERIC Digest*, 35, 1986, http://www.ericdigests.org/pre-925/nature.htm.
4. Beauchamp G. and Parkinson J., “Beyond the ‘wow’ factor: developing interactivity with the interactive whiteboard”, *School Science Review*, 86, 313, 2005, pp. 97-103.
5. Betcher C. and Lee M., *The interactive whiteboard revolution. Teaching with IWBs*, Camberwell Victoria, Acer Press, 2009.
6. Bonaiuti G., *Didattica attiva con la LIM. Metodologie, strumenti e materiali con la Lavagna Interattiva Multimediale*, Trento, Erickson, 2009.
7. Crowder D.A., *Google Earth for Dummies*, Hoboken NJ, Wiley, 2007.
8. Department of Land Affairs – Eastern Cape – South Africa, *Introducing GIS for Theachers and Learners*, 2009, http://linfiniti.com/dla/.
9. De Vecchis G. and Pesaresi C., *Dal banco al satellite. Fare geografia con le nuove tecnologie*, Rome, Carocci, 2011.
10. Edelson D.E., *Geographic Literacy in U.S. by 2025*, 2009, http://www.esri.com/news/arcnews/spring09articles/geographic-literacy.html.
11. Favretto A., *I mappamondi virtuali. Uno strumento per la didattica della geografia e della cartografia*, Bologna, Pàtron, 2009.

12. Istituto Nazionale di Documentazione Innnovazione e Ricerca Educativa – INDIRE, *Scuola digitale*, http://www.scuola-digitale.it/.
13. Kerski J.J. and Clark J., *The GIS Guide to Public Domain Data*, Redlands, California, ESRI Press, 2012.
14. Lazzarin G., “I programmi per la visualizzazione delle immagini della Terra come ausilio didattico all’insegnamento della geografia: Google Earth e NASA World Wind”, *Bollettino dell’Associazione Italiana di cartografia*, 129-131, 2007.
15. Leonardi S., “LIM e pratiche di insegnamento: quali sfide per la valutazione?”, *Form@re*, 78, 2012, pp. 11-17.
16. Longley P., Goodchild M., Maguire D. and Rhind D., *Geographic Information Systems and Science*, Hoboken NJ, Wiley, 2005.
17. Macchi G., *Spazio e misura*, Siena, Unisi Manuali, 2009, http://www.archeogr.unisi.it/spazioemisura/.
18. Madsen L.M. and Nielsen T.T., “Learning to do geography? University students posing questions in GIS laboratory exercises”, *Norsk Geografisk Tidsskrift – Norwegian Journal of Geography*, 67, 3, 2013, pp. 157-161, http://dx.doi.org/10.1080/00291951.2013.803259.
19. Magnaterra T., “La LIM in classe: un catalogo possibile”, *Form@re*, 10, 2010, pp. 20-26.
20. Masser I., *Building European Spatial Data Infrastructures*, Redlands, California, ESRI Press, 2010.
21. National Academy of Sciences, *Learning to think spatially: GIS as support systems in the K-12 Curriculum*, Washington, The National Academy Press, 2006.
22. National Geographic Society – The National Geographic Education Foundation, *Final Report*, Washington DC, National Geographic-Roper Public Affairs, Geographic Literacy Study, 2006, http://www.nationalgeographic.com/roper2006/findings.html.
23. Porter J.C., *Encounter World Regional Geography*, New Jersey, Pearson, 2011.
24. Porter J.C., *Encounter Human Geography*, New Jersey, Pearson, 2012.
25. Sandvik B., *KML for Thematic Mapping*, MSc in Geographical Information Science, University of Edimburgh, 2008a.
26. Sandvik B., *Thematic Mapping Engine*, MSc in Geographical Information Science, University of Edimburgh, 2008b.
27. Sandvik B., *Thematic Mapping*, http://thematicmapping.org/.
28. Schultz R.B., Kerski J.J. and Patterson T.C., “The Use of Virtual Globes as a Spatial Teaching Tool with Suggestions for Metadata Standards”, *Journal of Geography*, 107, 1, 2008, pp. 27-34.
29. Schuurman N., “Tweet Me Your Talk: Geographical Learning and Knowledge Production 2.0”, *The professional Geographer*, 65, 3, 2013, pp. 369-377.
30. Stuart Sinton D. and Lund J.J., *Understanding Place. GIS and Mapping across the Curriculum*, Redlands, California, ESRI Press, 2007.
31. Tomlison R., *Thinking About GIS*, Redlands, California, ESRI Press, 2007.
32. Zambotti F., *Didattica inclusiva con la LIM. Strategie e materiali per l’individualizzazione*, Trento, Erikson, 2010.